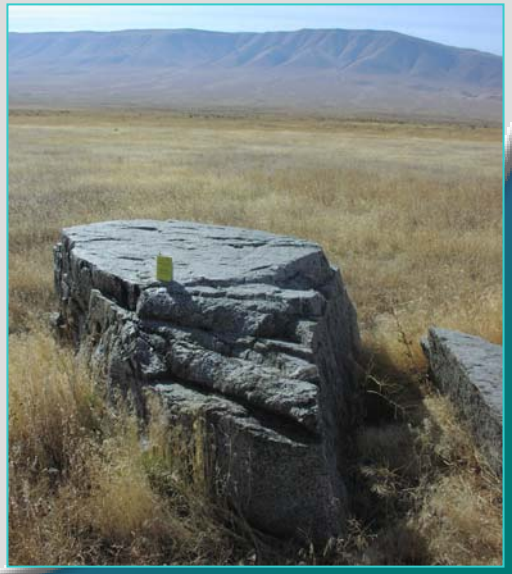
Erratic Behavior on Rattlesnake Mountain, Hanford Reach National Monument, South-Central Washington

Bruce Bjornstad, Pacific Northwest National Laboratory

Elysia Jennett, Northern Arizona University

Jenna Gaston, U.S. Fish and Wildlife Service

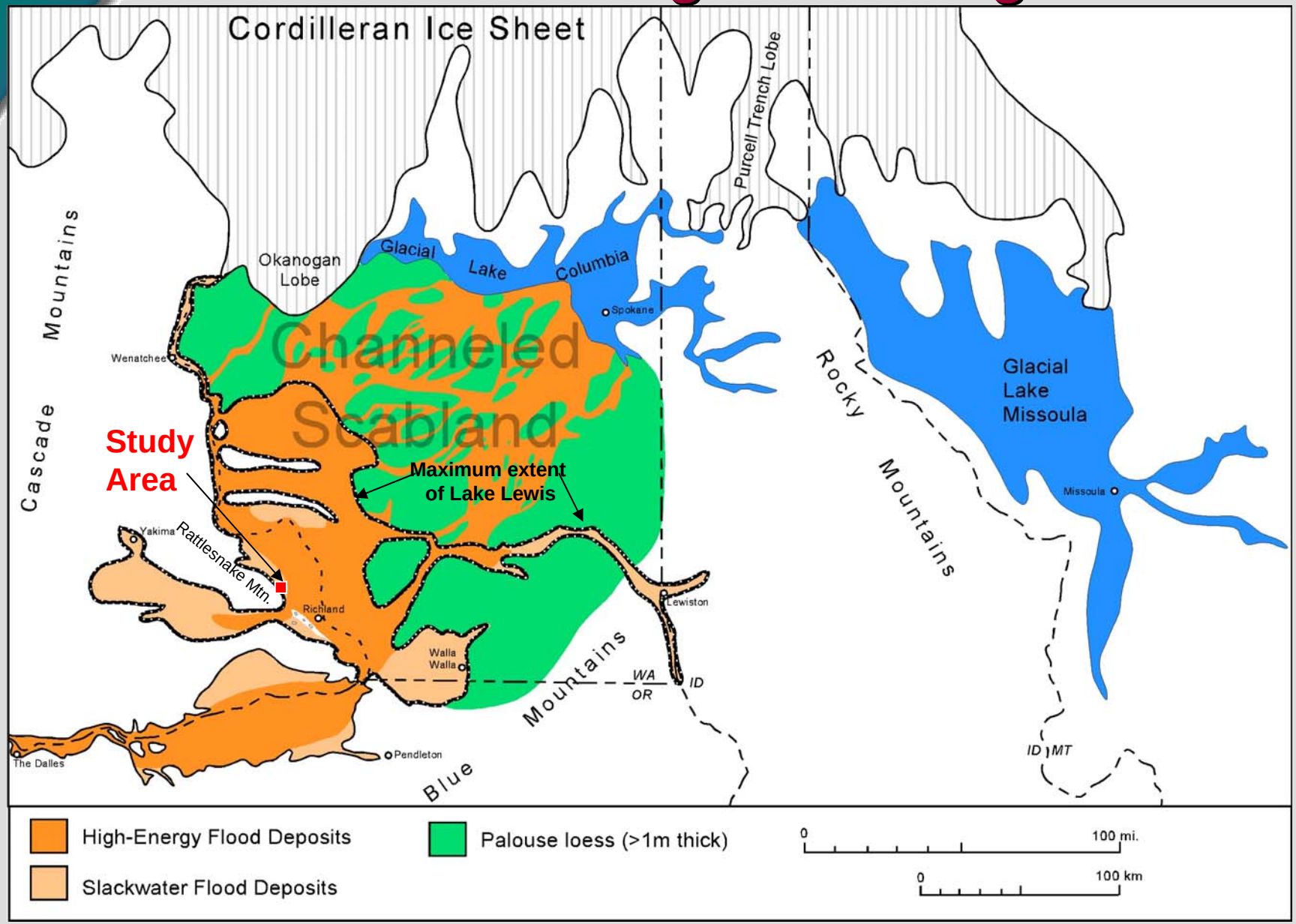
Gary Kleinknecht, Kamiakin High School



Geological Society of America Annual Meeting
Seattle, WA
November 3, 2003

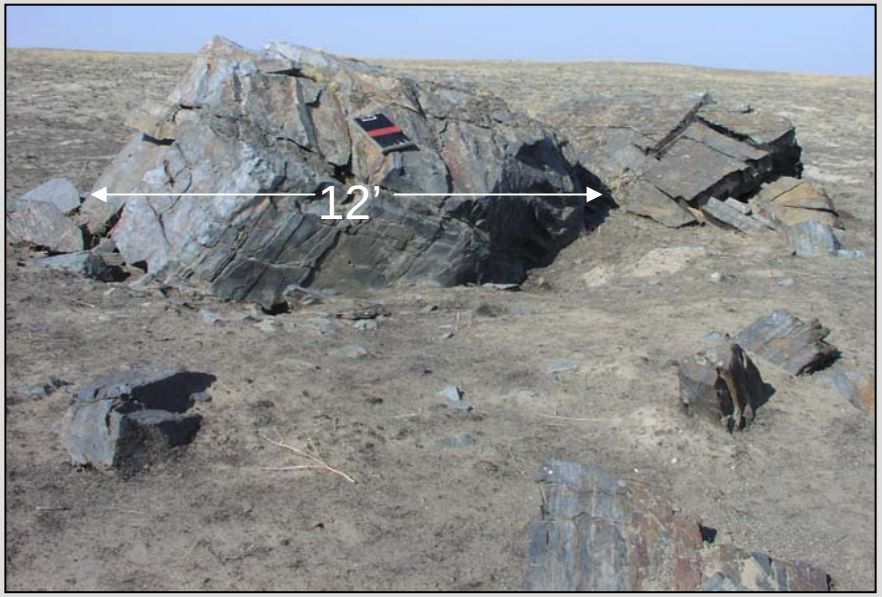
Battelle

Area of Ice-Age Flooding



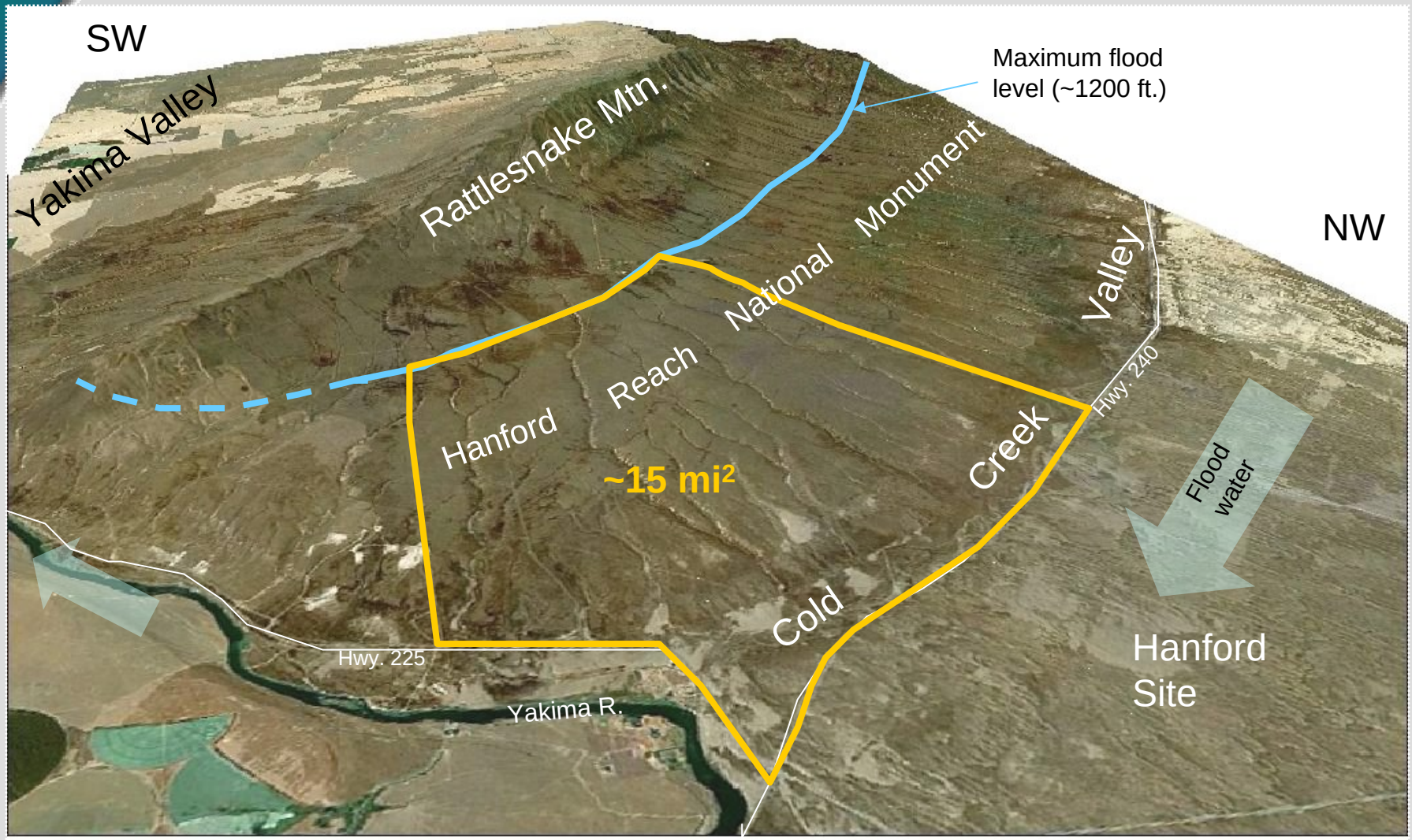
Ice-rafted debris collected in slack-water areas along the floods path

Conceptualization of the Bellevue erratic in Oregon's Willamette Valley by artists Ominski and Swaren



Comparable erratic on Rattlesnake Mtn.

Study Area



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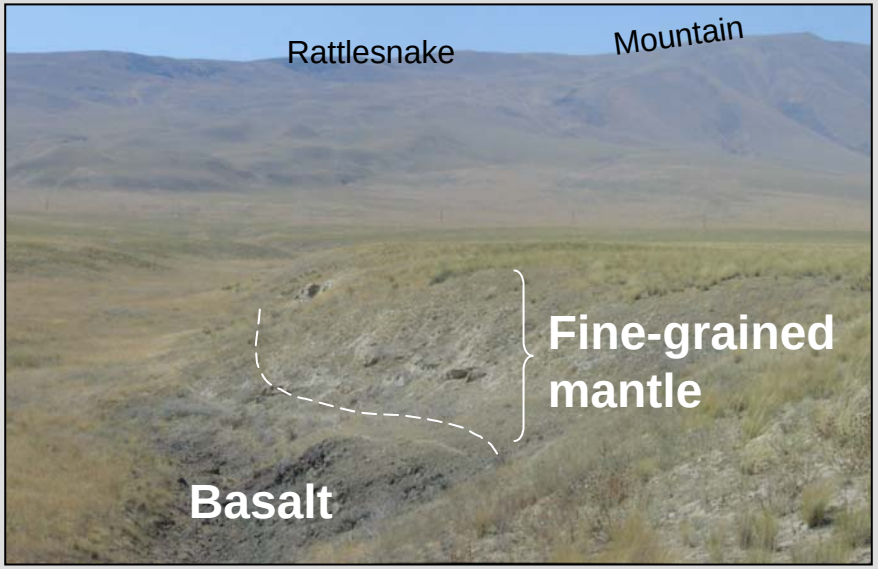
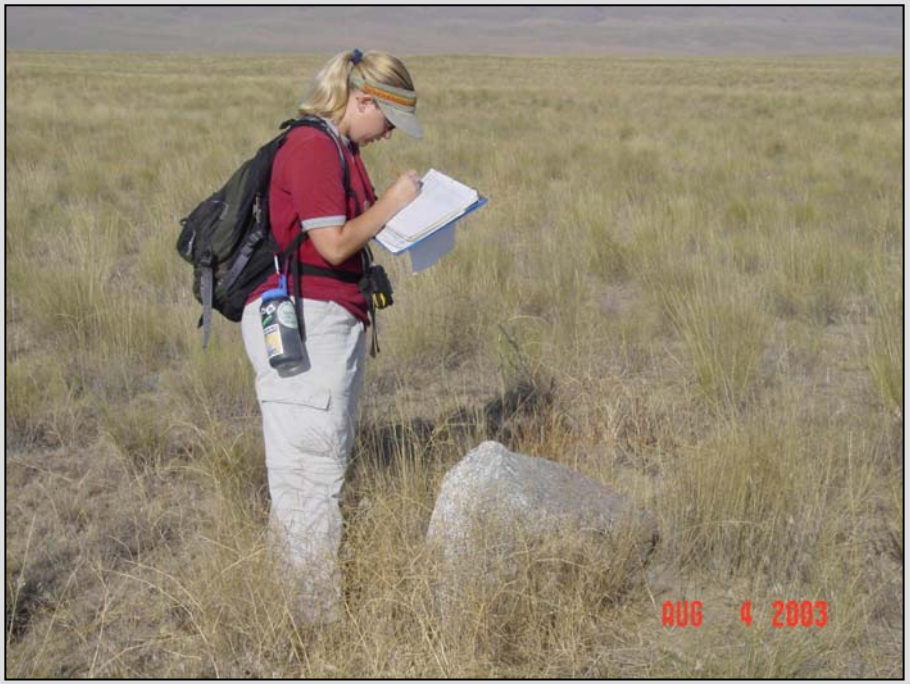
Environmental Setting of Study Area



- Pristine, undisturbed, and protected area for last 60 years, now part of the HRNM
- Sparsely vegetated. Totally burnt off in 2000 wildfire, and partially burnt in 2003.
- Gently sloping, low-relief slope of Rattlesnake Mtn.
- Only indigenous rock = dark Columbia River Basalt (exposed at base of arroyos)
- Thin ($\leq$20 ft), fine-grained mantle of Holocene loess, slopewash, and/or slack-water flood deposits above basalt
- Ice-rafted debris is easily recognized in this environment.

Data Collection

- Type of debris
- GPS location
- Elevation
- Size
- Lithology
- Roundness
- Surface characteristics



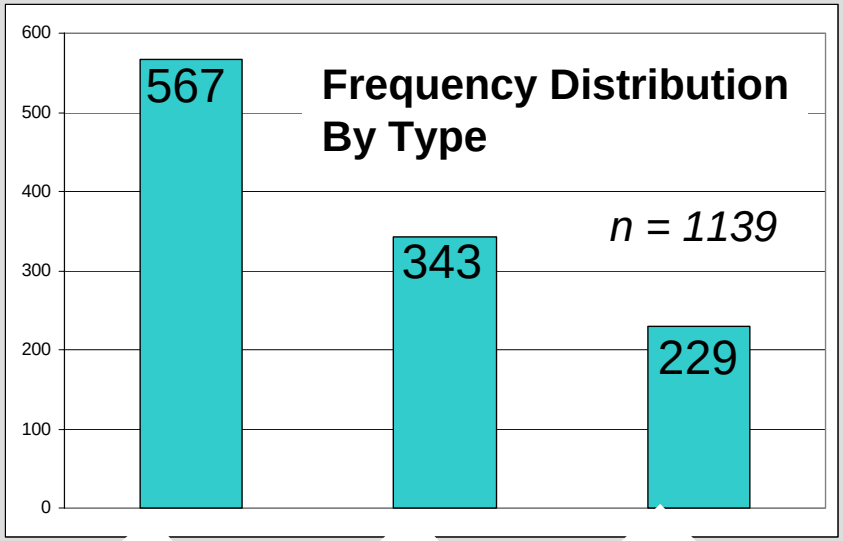
- *Erratic size limit $\geq$1 ft^2*
  (Max. observed cross-sectional area)
- *Data points = 1139*
- *Area $\sim$ 15 mi^2*

Three Types of Ice-Rafted Debris

1. Isolated erratics

2. Erratic clusters

3. Bergmounds



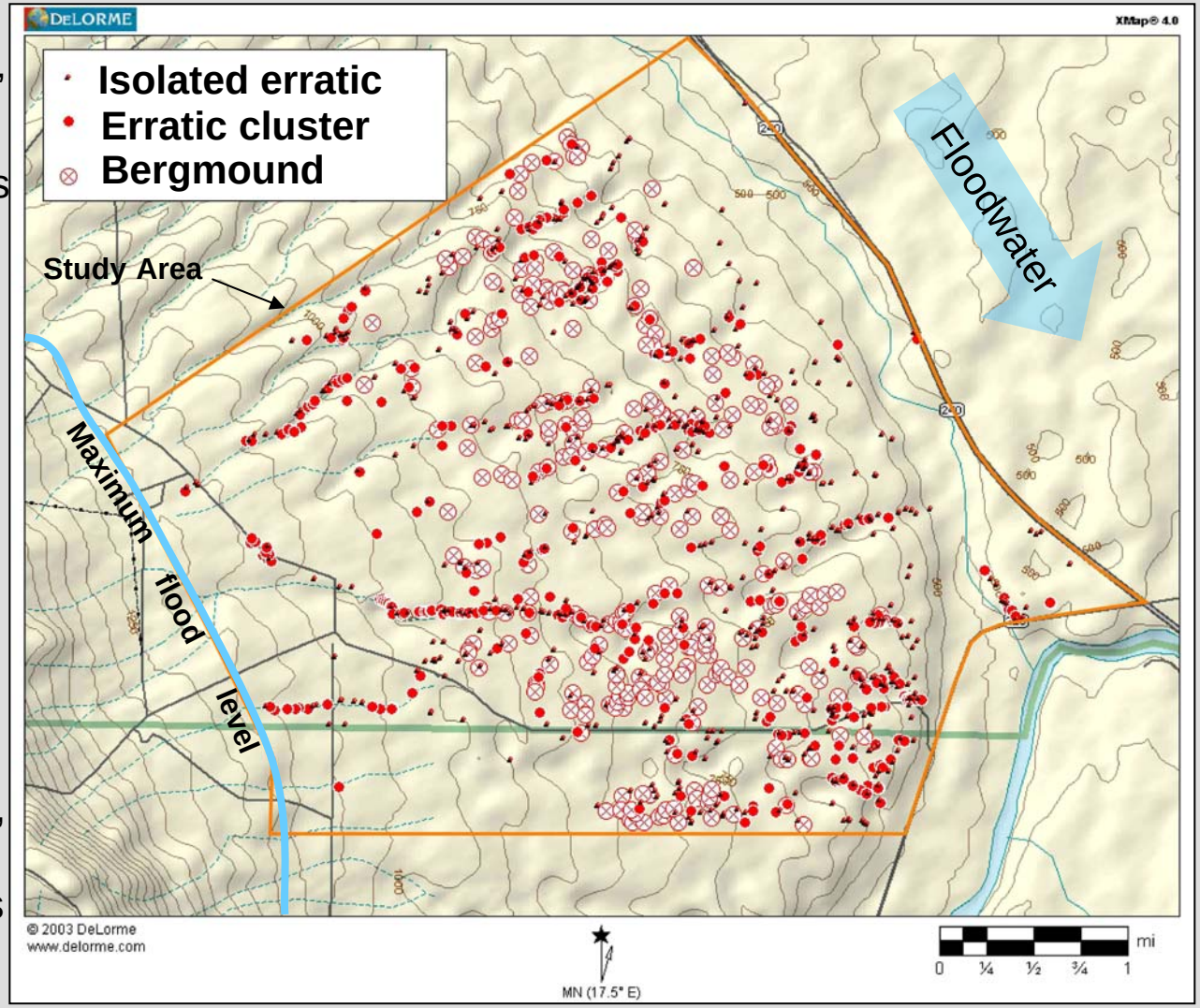
Isolated Erratics

Erratic Clusters

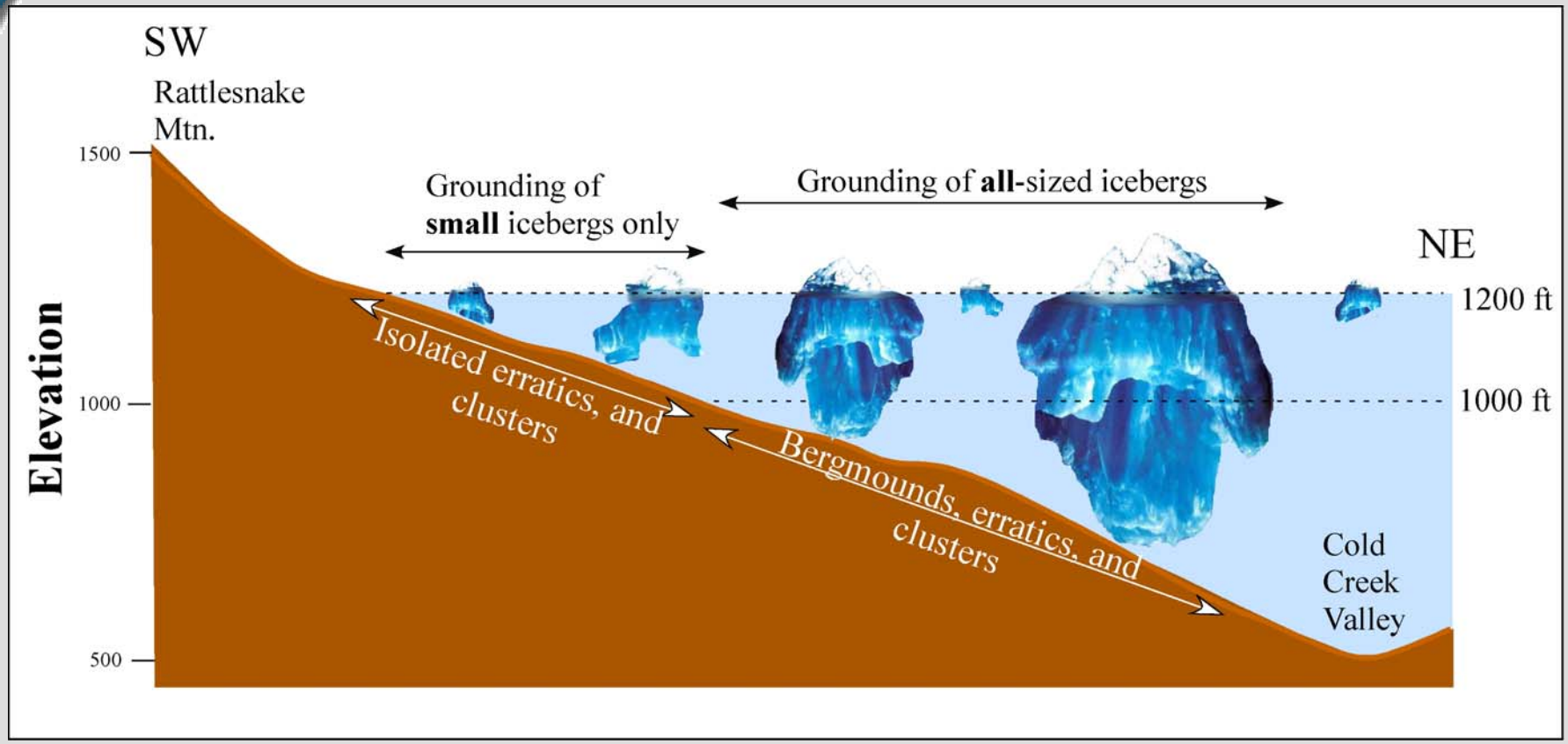
Berg-mounds

Spatial Distribution of Ice-Rafted Debris

- Maximum elevation =1165’
- Amount of ice-rafted debris increases downslope
- Bergmounds restricted to 600-1000 ft elevation
- Buried erratics exhumed along roadways
- Erratics, especially in clusters, align with flood-drowned arroyos. At lower elevations erratics are concentrated along leeward, southerly facing arroyo slopes. At higher elevations they’re concentrated at bottoms of arroyos.

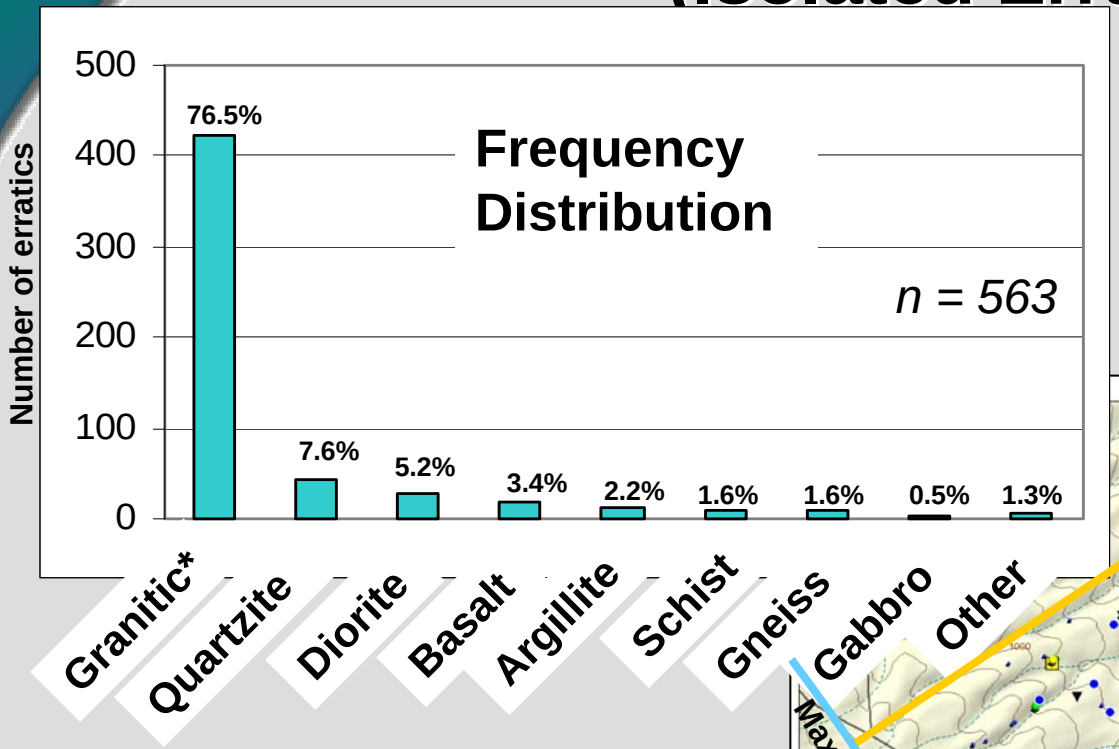


Model to Explain Limited Distribution of Bergmounds

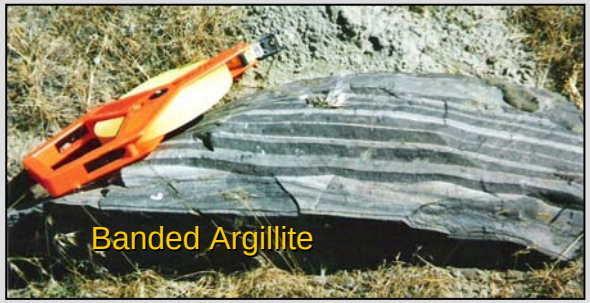


Bergmounds are not observed above 1000 ft elev., even though the floodwaters extended up to 1200 ft. The largest icebergs, required to generate bergmounds, apparently became grounded ≥200 ft below the maximum lake level.

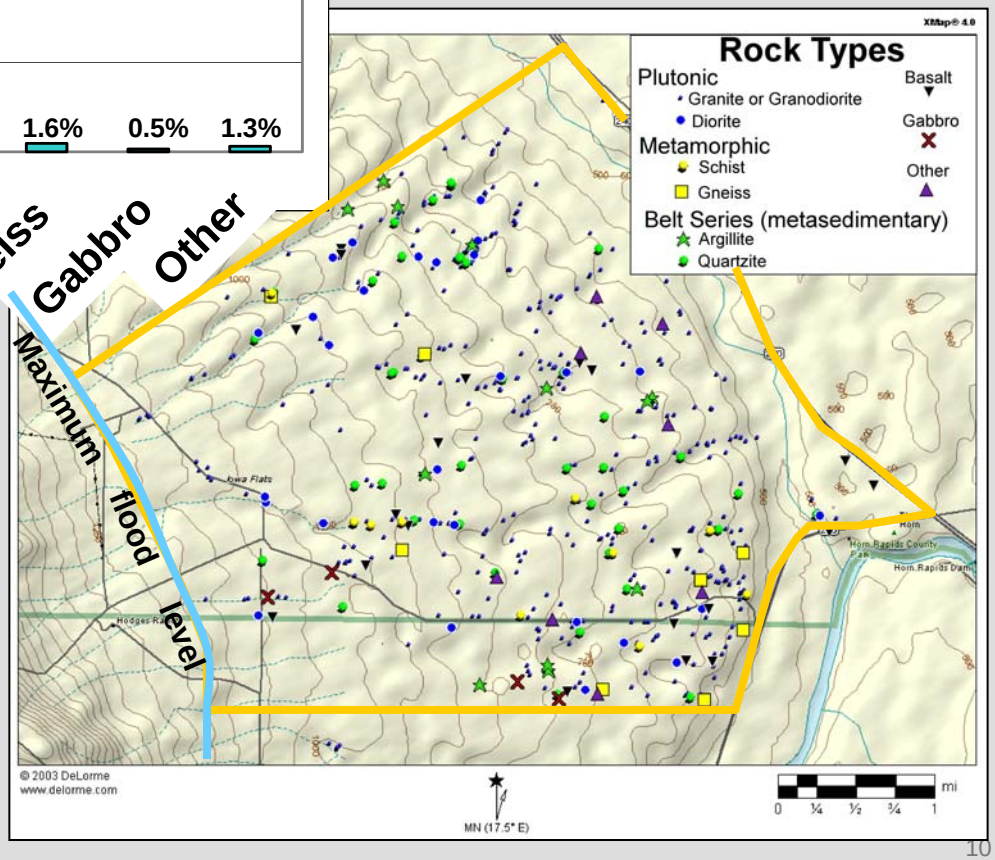
Lithology
(Isolated Erratics)



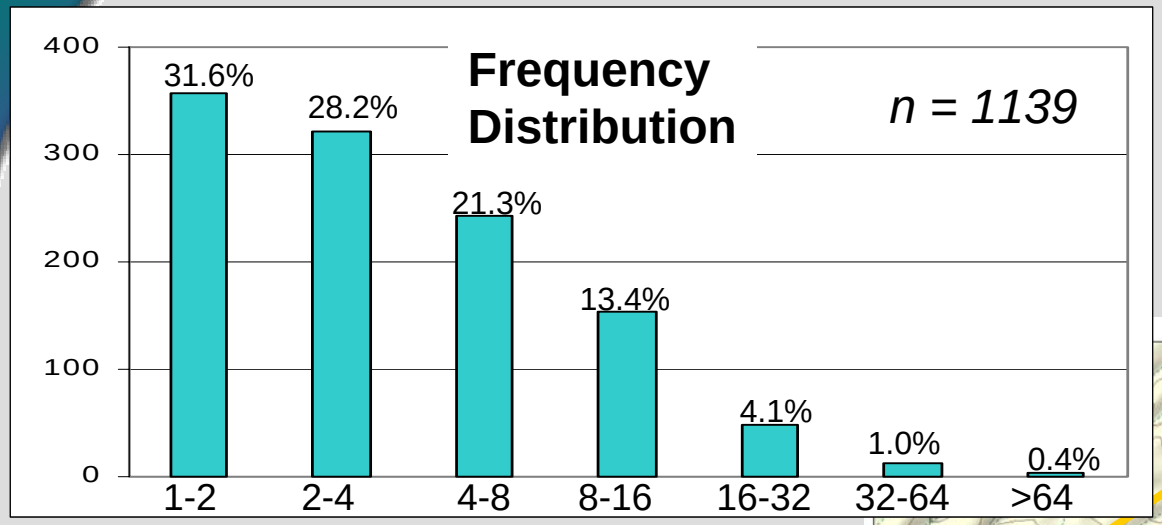
*Granitic = granite or granodiorite



Spatial Distribution

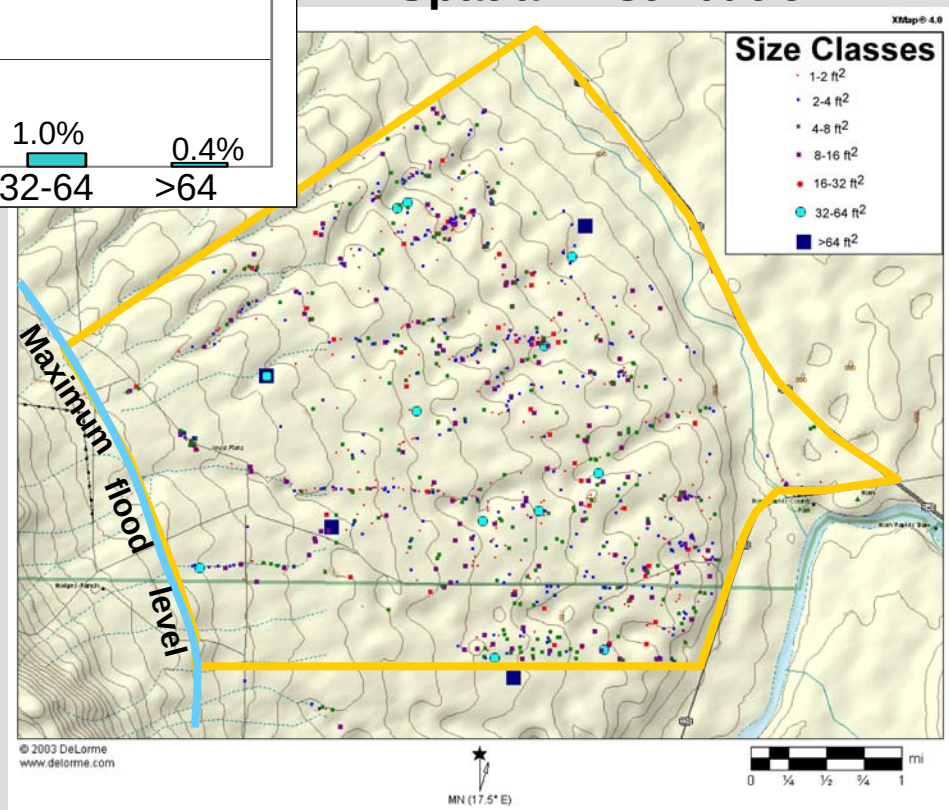


Size of Erratics*



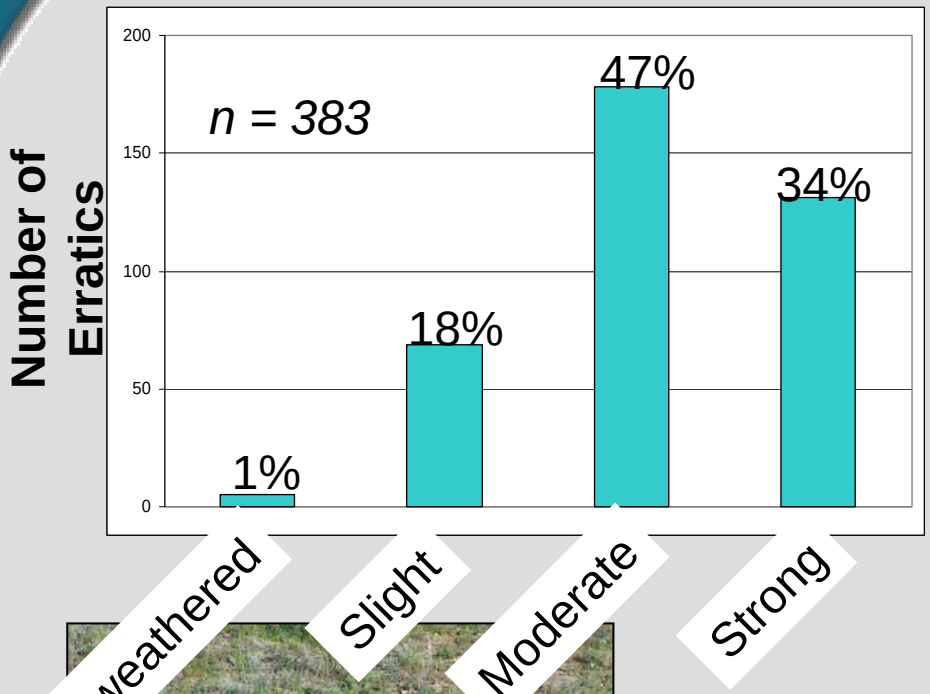
Size Class
(Max. cross-sectional area in ft^2)

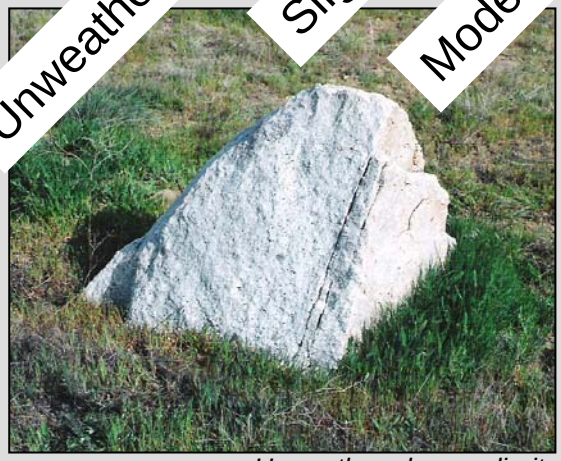
Spatial Distribution



*isolated erratics and maximum size erratic in groupings

Surface Weathering
(Isolated Granitic Erratics)



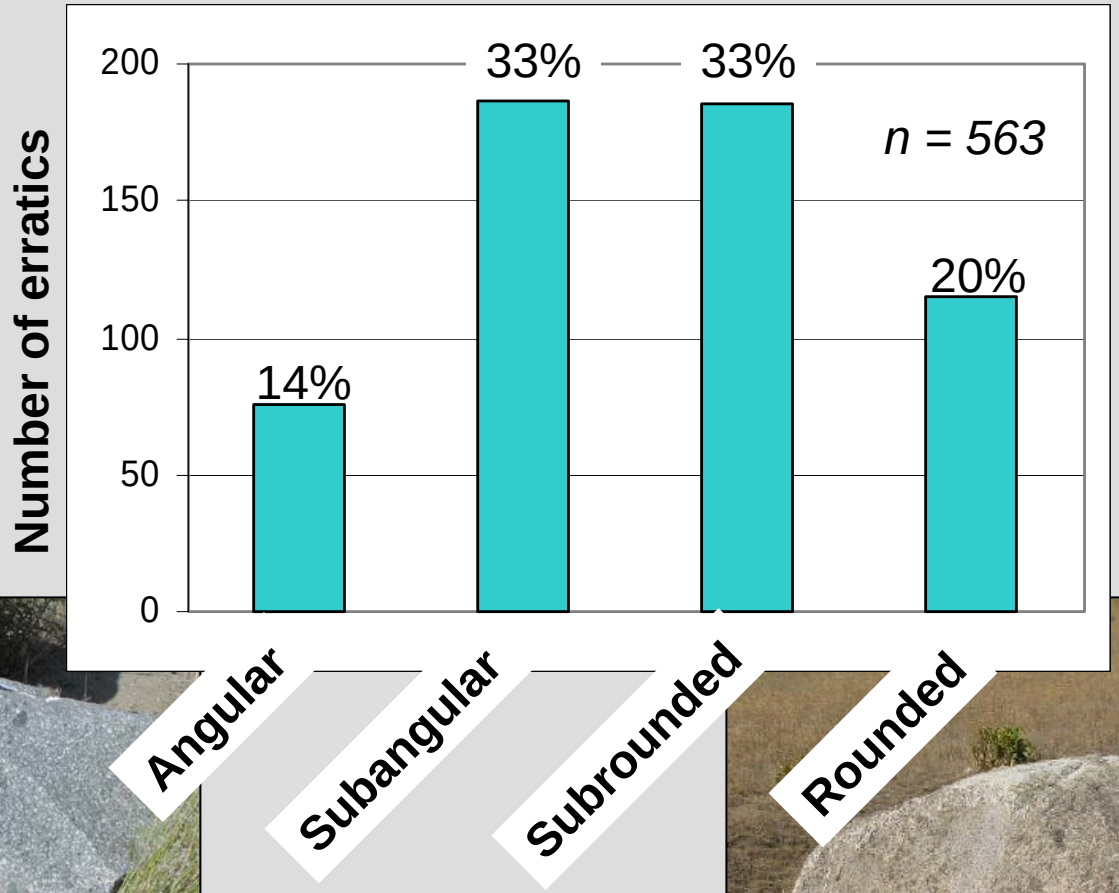


Unweathered granodiorite

Close-up of strongly weathered, spalled, granodiorite surface

Strongly weathered granodiorite with desert varnish

Roundness
(Isolated Erratics)



Angular, unweathered diorite

Rounded, weathered granodiorite

Could Weathering and Roundness be an Indication of Time Since Flooding?

- There is a general trend for fresh, unweathered erratics to be more angular - and weathered ones to be more rounded.
- This may suggest that roundness is more a function of in-situ weathering than abrasion.
- Some weathered and rounded erratics might be expected to predate rafting, but probably not 50% as observed on Rattlesnake Mtn.
- Therefore, a significant number of rounded and weathered erratics might be from pre-Wisconsin flood events.

Roundness ↓ / Weathering →	Unweathered	Slightly weathered	Moderately weathered	Strongly weathered
Angular	1*	12	20	5
Sub-angular	4	24	64	33
Sub-rounded	0	22	61	49
Rounded	0	11	30	42

** Number of isolated, granitic erratics (n=378)*

Summary

- Over 95% of erratics are exotic, and over 75% are granitic; rock types are consistent with sources ≥100 mi away, N and NE of the Columbia Plateau.
- An increase in the amount of ice-rafted debris downslope is consistent with a greater number of less-than-maximum floods.
- Most erratics are small, 60% are less than 2ft X 2ft in plan view.
- An increased number of erratics lie along roadways, exhumed during road construction. This suggests that many more erratics than appear on the surface, lie buried within the fine-grained soil mantle.
- Distribution patterns are different for isolated erratics, erratic clusters, and bergmounds:
  - Alignment of erratics along arroyos could be due to: 1) eddy currents during flooding, created by variable flow velocities across an uneven surface, or 2) exhumation via stream erosion along the arroyo.
  - Bergmounds don't extend above 1000 ft elev., probably because larger icebergs naturally became grounded on the gently sloping lake bottom further from the ancient lakeshore.
- Most erratics from the recent floods might be expected to have only angular, slightly weathered surfaces. However, over 50% of erratics are rounded to subrounded. This, combined with the observation that >80% of erratics are moderately to strongly weathered, suggests that a substantial number may be from older, pre-Wisconsin floods.